Semi-Annual Status Report

Period 1 January 1975 - 31 December 1975

NASA Grant NGR 03-002-332

INFRARED SPECTROSCOPY OF THE PLANETS FROM 1 - 5.6μ WITH THE MEDIUM RESOLUTION LPL FOURIER SPECTROMETER FROM THE THE NASA AIRBORNE IR OBSERVATORY

(NASA-CR-146029) INFRARED SPECTROSCOPY OF THE PLANETS FROM 1-5.6 MICRONS WITH THE MEDIUM RESOLUTION LPL FOURIER SPECTROMETER FROM THE NASA AIRBORNE IR OBSERVATORY Semiannual Status Report, 1 Jan. - 31 Dec. 00/98 N76-70865 Unclas 06794

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The following areas of activity received major emphasis during this report period:

1. Analysis of the IR spectrum of Jupiter recorded from the Kuiper Airborne Observatory in October, 1974. This required ground-based observations of Jupiter and extensive laboratory measurements.

2. Initialized the high resolution airborne spectrometer development project.

3. Conducted flights on the airborne observatory devoted to spectroscopic observations of Jupiter in the 5μ, 2.7μ and 1.9μ regions.

4. Search for adequate computer support for the airborne IR project.

Each of these areas is discussed in greater detail below:

1. In late October, 1974 we successfully recorded from the Kuiper Airborne Observatory a moderate resolution (2.4 cm^{-1}) spectrum of Jupiter in the 5μ region. An immediate result of these observations was the detection of H_2O vapor in Jupiter's atmosphere. A preliminary account of this identification was presented at the 1975 annual meeting of the Division for Planetary Sciences of the American Astronomical Society held in Columbia, Maryland. (Treffers, R.T., Larson, H. P., Fink, U., and Gautier, N. (1975). B.A.A.S., 7, 380). A complete description of this work was published in mid-1975 (Larson, H. P., Fink, U., Treffers, R. T., and Gautier, T. (1975), Ap. J., L137). Further analysis of this spectrum revealed additional absorptions that could not be immediately assigned to Jupiter's known atmospheric constituents. In an attempt to identify these molecules we initiated a program of laboratory comparison measurements. Several dozen gases holding promise for detailed comparison with Jupiter's high altitude spectrum were screened from a much larger list. From this preliminary survey three molecules

(GeH_4, HCN, and CO_2) were found to match some of the most prominent unknown Jovian absorptions. These results were presented at the Jupiter Conference held in Tucson, Arizona in May, 1975. Many of our recent results on Jupiter will be reviewed in a chapter[1] of the book Jupiter, the Giant Planet (T. Gehrels, editor), intended as a sourcebook for all recent investigations of this planet.

The H_2O lines detected in our high-altitude spectrum of Jupiter provide excellent material for defining vertical models based on radiative transfer of Jupiter's atmosphere below the visible cloud tops. No other physical measurements of this planet provide such detailed information. One of several important results of such modeling will be the oxygen abundance on Jupiter, a number that preliminary analysis indicated is substantially lower than the solar value. A graduate student who has become interested in this problem may develop this theoretical analysis into his doctoral dissertation topic.

2. By the end of 1975 good progress had been made on construction of a prototype spectrometer intended to replace our existing instrumentation for airborne IR astronomy. The new spectrometer will provide higher spectral resolution than is currently available to the project and which will be especially important for future observations of Jupiter. Also, the new spectrometer is designed to be insensitive to the mechanical vibrations and scintillation noise present at the airborne observatory that seriously degrade the performance of our existing spectrometer, especially at short wavelengths. This project is being conducted in collaboration with Pierre Connes and the Fourier spectroscopy group at Laboratoire Aimé Cotton, CNRS, Paris, France.

[1] The Infrared Spectrum of Jupiter: An Introduction and a Review, S. Ridgway, H. Larson, and U. Fink.

3. In December 1975 we continued our high-altitude observing program with additional flights on the Kuiper Airborne Observatory devoted to observationsof Jupiter. We sought higher spectral resolution on Jupiter in the 5μ spectral region. These observations have already been processed, revealing a high quality spectrum at 5 x the resolution of our previous investigation. These new observations will greatly influence chemical and physical modeling of Jupiter's lower atmosphere and they will also increase the sensitivity of our search for additional trace atmospheric constituents on Jupiter.

During these 1975 flights we also conducted observations of Jupiter in the 2.7 and 1.9μ regions. The Jovian atmosphere is transparent here but telluric H_2O vapor absorptions obscure these Jovian windows in all ground-based observations. We also devoted a portion of some of our flights to exploratory observations of Mars from 1-5.6μ. None of these observations have yet been processed but real-time spectral display during the flights indicated that useful results were being acquired.

Table I summarizes our December 1975 flights. The results of the first three flights were available so quickly because we established a complete off-line data processing capability at NASA-Ames using the airborne facility's computers and personnel. Evaluation of fully processed spectral data during the flight program permitted us to use available flights to maximum advantage.

4. Fourier spectroscopy is totally dependent upon digital computation and most modern Fourier spectrometers now employ minicomputers for on-line data acquisition. Our spectrometer does provide real-time spectral display by a special Fourier transform computer, but this computer cannot be used for other real-time tasks nor can it be used for off-line data processing. We

TABLE I

IR Spectral Observations from the Kuiper Airborne Observatory in 1975

Date	Objects Observed	Spectral Region	Resolution	Observing Time
9 Dec 75	Jupiter	5μ	0.6 cm^{-1}	3^h7^m
11 Dec 75	Jupiter	5μ	0.6	3^h11^m
	Moon	5μ	0.6	0^h13^m
12 Dec 75	Jupiter	5μ	0.6	2^h39^m
	Moon	5μ	0.6	0^h15^m
	Mars	5μ	0.6/2.5	0^h50^m
15 Dec 75	Jupiter	1-4μ	0.6	2^h28^m
	Moon	1-4μ	0.3	0^h20^m
	Mars	1-4μ	0.6	0^h55^m
16 Dec 75	Jupiter	1-4μ	2.5	2^h45^m
	Moon	1-4μ	2.5	0^h12^m
	Mars	1-4μ	2.5	0^h55^m

depend entirely upon general-purpose computer installations for our data processing and spectral analysis. The project has only limited access to this type of computer and, of course, such a computer cannot accompany the experiment on major expeditions away from the laboratory, thus depriving the experiment of the only means to evaluate its total performance.

The success of our high-altitude observing program combined with active ground-based observations and laboratory measurements thoroughly saturated the Laboratory's computer, an IBM 1130. In August, 1975 this computer was replaced with a more modern facility, a PDP 11/40. We hoped that with this new computer we could reduce our backlog of data processing tasks and spend more time on spectral analysis, but the new computer has been a big disappointment. It is no faster than our previous computer for our time-consuming data processing operations, yet it costs more to operate and we probably will have less access to it since a larger group of users is now employing it. The IR project has been further compromised by the Laboratory Director's arbitrary dismissal of its only data processor without any consultation with the principal investigators (H. P. Larson and U. Fink) who provided up to 75% of this person's salary from two grants. As a consequence of these changes, the IR project now commands less computer support than ever for an experimental program producing more observational material and more opportunities for theoretical analysis.

We see only one solution to this problem: providing the IR project with its own, independent computer facility. This could be incorporated into the new spectrometer as an on-line data acquisition system, but configured so that it can readily serve as a fast off-line data processing and analysis center for the project's needs. Within present budgetary constraints we cannot hope to assemble such a computing system, costing about $60,000, in less than a two or three year period. Until then we will be constrained to working only on the most urgent projects while delaying or sidelining much fundamental work. We can illustrate this situation with the following examples applying specifically to the airborne spectroscopy project:

a. Ground-based high resolution observations of Jupiter recorded in late September, 1975 in preparation for December observations of Jupiter from the airborne observatory have not yet been processed.

b. Laboratory comparison spectra recorded in the spring of 1975 at the anticipated resolution of our December Jupiter observations are not yet processed.

c. Theoretical modeling of Jupiter's atmosphere using the high altitude spectral data has not progressed as rapidly as possible since data processing tasks have monopolized the IR project's use of the Laboratory's computer.

While our most recent airborne observations of Jupiter are already processed, they cannot lead to new scientific results until supporting activities such as those listed above can also receive generous amounts of time on a fast computer.